Thought of Dr Leggett

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The Problems of Physics. By A. J. Leggett. *Oxford University Press: 1987. Pp.192. Hbk £15, $17.95; pbk £4.95, $10.95.*

To those who have followed Leggett's work professionally, this book will not come as a surprise. It is written in the style which is so characteristic of the author: complex conceptual questions are broken up, inessential pieces are removed and the ideas are finally presented with a simplicity that no one can imitate. Nonetheless, whilst reading the book I could not help asking myself how it would be received by those less familiar with Leggett's writings. I shall return to this point later. For the moment, it seems to me that no matter how one is swayed by one's own personal prejudices, the book is undeniably an exquisite presentation of frontier areas of contemporary physics. The questioning attitude can be a vital source of inspiration to young and would-be physicists. We all know that strong pressures to conform to existing paradigms come much too early in our lives.

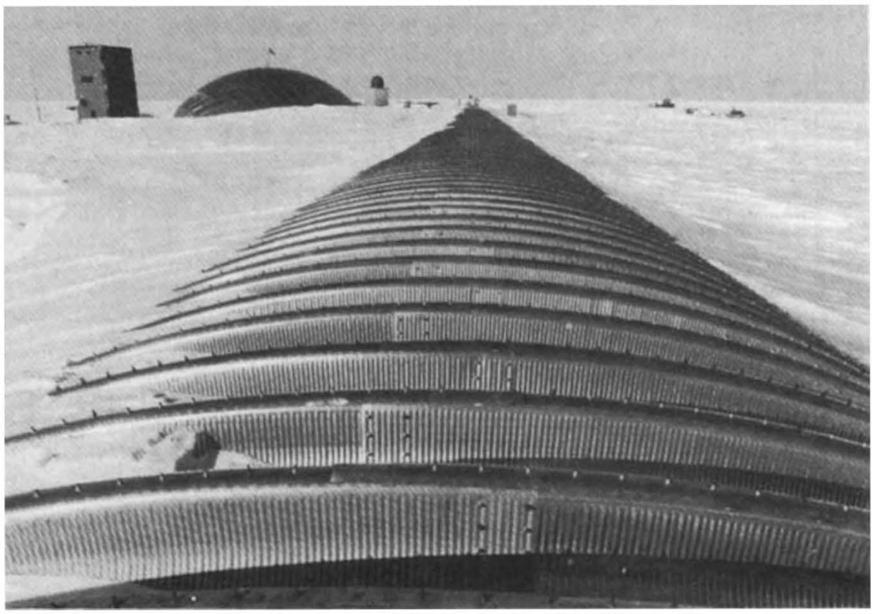
Elementary particle physics and cosmology are currently undergoing revolutionary changes. Quantum chromodynamics has ushered in a new era in which the question "What are things made of?" has reached a new level of simplicity. We have learnt that the fundamental interactions owe their form to deep concepts such as gauge invariance. We have also learnt that two of those interactions, the electromagnetic and the weak, can be unified, which has led to spectacular predictions that have been experimentally well verified. To explain these developments in a language that is understandable to a non-expert needs an unusual amount of insight, and I suspect that the clarity with which they are discussed in this book will be welcome by all.

A point that Leggett makes over and over again, and one that is worth more than a pause, is that in physics we are continually making extrapolations. Often the laws that are tested firmly on a given scale are assumed to hold on scales which are unimaginably different. Leggett illustrates the point with an almost poetic poignancy: "If we imagine a microbe confined to the surface of a microscopic speck of dust floating in the middle of St Paul's Cathedral, the microbe's problem in inferring the properties of the Cathedral, or even the earth as a whole, would be trivial compared with ours".

Here, of course, he means the reality that a cosmologist faces. But then did not Newton also make such an extrapolation when he successfully described the motion of the planets? How are we able to make such extrapolations in physics? What guides us? What are the tools of present-day cosmology? How can we describe the first 10^{-35} seconds after the Big Bang? It almost sounds fantastic to a layman, and yet cosmologists are making steady progress in finding answers to these questions. New concrete concepts and tools of particle physics are being used successfully. The idea of broken symmetry, borrowed from condensed-matter physics, is exploited to propose how, as the Universe expanded, and cooled, the various symmetries were progressively broken, and the Universe evolved to the state that we live in. The scheme, however grand and elegant it may sound, is not without its difficulties. Almost all versions of this scenario predict unobserved debris of the Big Bang — monopoles, cosmic strings and so on. It is only recently that those pursuing the concept of an inflationary universe have begun to come to terms with such difficulties.

Leggett then moves on to physics on an entirely different scale, a scale that we are familiar with in our everyday life, the so-called condensed-matter physics. The subject matter in this area is extraordinarily diverse, so some important developments are sampled. In this respect I sometimes wonder how old-fashioned the textbooks are, and how naive the views of some of my colleagues are as to what condensed-matter physics is. Leggett has strived marvellously to dispel some of the antiquated notions in common currency. The sample that he provides is truly representative of the modern developments, and even experts will find the exposition insightful. But what is perhaps more important is the underlying view that the author holds. As he says, it is not uncommon to hear "that there are no new laws of nature to be discovered by studying condensed matter as such, since all behaviour of such matter follows, in principle, from the behaviour of its atomic or subatomic constituents; and second if this is so, then the study of complex matter cannot be as 'fundamental' as the study of the constituents themselves — indeed, that it is really rather a trivial occupation by comparison".

Leggett then goes on to expose the fallacious nature of this view, and in this in my opinion he has done a much-needed service to the community. His view that the most important advances in this area come about by the emergence of *qualitatively* new concepts is a point that even the practitioners of the field sometimes fail to recognize. Some of these concepts such as voltage, temperature, entropy and so on are so ingrained in our education that we fail to recognize their true role in the development of the field. Others, such as broken symmetry and universality classes, have found such wide applications that some of us tend to forget where they came from. I leave it as an amusing exercise to



Hidden depths — the Amundsen–Scott Station at the South Pole. The picture is taken from International Research in the Antarctic, *which is based on reports from working groups of SCAR, the Scientific Committee on Antarctic Research. Published by the International Council of Scientific Committees with Oxford University Press, the book costs £25, $39.95.*